TENT COOPERATION TREA

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

To:

SKUHRA, Udo
Friedrichstr. 31
80801 München
ALLEMAGNE

Date of mailing (day/month/year)
18 December 2000 (18.12.00)

Applicant's or agent's file reference
GR98P4747P

IMPORTANT NOTIFICATION

International application No.
PCT/EP99/08361

International filing date (day/month/year)
02 November 1999 (02.11.99)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [ ] the agent [X] the common representative

Name and Address
INFINEON TECHNOLOGIES AG
Zedlitz, Peter
Postfach 22 13 17
D-80503 München
Germany

State of Nationality:
State of Residence:
Telephone No.: 089 636-82819
Facsimile No.: 089 636-81857
Teleprinter No.:

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[X] the person [X] the name [X] the address [ ] the nationality [ ] the residence

Name and Address
SKUHRA, Udo
Friedrichstr. 31
80801 München
Germany

State of Nationality:
State of Residence:
Telephone No.:
Facsimile No.:
Teleprinter No.:

3. Further observations, if necessary:
An agent has been appointed.

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer
Christine Carrié

Telephone No.: (41-22) 338.83.38

Form PCT/IB/306 (March 1994)

003728931

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 28 August 2000 (28.08.00)	
International application No. PCT/EP99/08361	**Applicant's or agent's file reference** GR98P4747P
International filing date (day/month/year) 02 November 1999 (02.11.99)	**Priority date** (day/month/year) 10 November 1998 (10.11.98)
Applicant HÖFER, Gerald	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

09 June 2000 (09.06.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Beatriz Morariu

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

COMMUNICATION OF
INTERNATIONAL APPLICATIONS

(PCT Article 20)

To:

Assistant Commissioner for Patents
United States Patent and Trademark
Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as designated Office

Date of mailing:
10 April 2000 (10.04.00)

The International Bureau transmits herewith copies of the international applications having the following international application numbers and international publication numbers:

International application no.:	International publication no.:
PCT/EP99/08361	

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer:

J. Zahra

Telephone No.: (41-22) 338.83.38

Copy for the designated Office (DO/US)

ENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

COMMUNICATION IN CASES FOR WHICH NO OTHER FORM IS APPLICABLE

To:
INFINEON TECHNOLOGIES AG
Zedlitz, Peter
D-80503 München
ALLEMAGNE

Date of mailing (*day/month/year*) 06 April 2000 (06.04.00)	
Applicant's or agent's file reference GR98P4747P	**REPLY DUE** see paragraph 1 below
International application No. PCT/EP99/08361	International filing date (*day/month/year*) 02 November 1999 (02.11.99)
Applicant INFINEON TECHNOLOGIES AG	

1. ☐ REPLY DUE within _____ months/days from the above date of mailing

☐ NO REPLY DUE, however, see below

☒ IMPORTANT COMMUNICATION

☐ INFORMATION ONLY

2. COMMUNICATION:

The international Bureau regrets to inform the aplicant that due to a late transmittal by the receiving Office (RO/EP), the above-identified application has not been published promptly after the expiration of 18 months from the priority, as provided in PCT Article 21(2) (a).

International publication will take place on 25 May 2000 (25.05.00).

Meanwhile, the international Bureau (WO) will communicate a copy of the international application to each designated Office, in accordance with Article 20.

A copy of this notification has been sent to the receiving Office (RO/EP), the International Searching Authority (ISA/EP) and to all designated Offices concerned.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer
Beatriz Morariu

Telephone No. (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
GR98P4747P		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 99/ 08361	02/11/1999	10/11/1998

Applicant

INFINEON TECHNOLOGIES AG et al.

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established by this Authority to read as follows:

   METHOD AND APPARATUS FOR DETERMINING PROPERTIES OF A SIGNAL TRANSMISSION CHANNEL

5. With regard to the **abstract**,

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [ ] as suggested by the applicant.

   [X] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
EP 99/08361

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L25/49 H04L5/14 H04L12/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04J H04Q H04M H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 825 823 A (OKUNEV YURI ET AL) 20 October 1998 (1998-10-20) abstract column 3, line 54 -column 4, line 37 column 5, line 65 -column 6, line 36; figure 2 column 7, line 19 - line 28 ---	1-13
X	WO 98 39866 A (3COM CORP) 11 September 1998 (1998-09-11) abstract page 7, line 6 -page 12, line 4 claims 1,13,14 figures 1,4 --- -/--	1-13

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 June 2000	13/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Koukourlis, S

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 17044 A (MOTOROLA INC) 23 April 1998 (1998-04-23) page 18, line 26 -page 26, line 13 page 3, line 3 -page 6, line 30 abstract	1-13
A	EP 0 833 481 A (TELIA AB) 1 April 1998 (1998-04-01) abstract column 2, line 39 - line 55	1
A	ITU-T RECOMMENDATION V.34 DATA COMMUNICATION OVER THE TELEPHONE NETWORK, September 1994 (1994-09), XP002100826 Geneva page 41, paragraph 11.2 -page 49, paragraph 11.4	1
A	US 5 793 809 A (HOLMQUIST KURT ERVIN) 11 August 1998 (1998-08-11) abstract column 1, line 9 - line 35 column 2, line 17 - line 46 column 4, line 12 - line 36 column 5, line 58 -column 6, line 22 column 7, line 39 - line 60	1-13
A	ANONYMOUS: "Improvement to Spectral Shaping Technique" IBM TECHNICAL DISCLOSURE BULLETIN, vol. 41, no. 415, 1 November 1998 (1998-11-01), XP002100049 New York, US the whole document	1-13
A	WO 98 37657 A (3COM CORP) 27 August 1998 (1998-08-27) page 37, line 7 -page 38, line 31 claims 21-27	1-13
A	EP 0 871 303 A (DEMJANENKO VICTOR ;HIRZEL FREDERIC J (US)) 14 October 1998 (1998-10-14) abstract page 3, line 18 - line 23 page 3, line 46 - line 48 page 4, line 54 -page 5, line 3 claims 1-3	1,12,13
A	EP 0 735 717 A (AT & T CORP) 2 October 1996 (1996-10-02) page 5, line 40 -page 6, line 2	1-13

-/--

INTERNATIONAL SEARCH REPORT

International Application No
[redacted]/EP 99/08361

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 13979 A (MOTOROLA INC) 2 April 1998 (1998-04-02) page 15, line 15 -page 16, line 2 claim 1	1,12,13
A	US 5 267 300 A (KAO MING-LUH ET AL) 30 November 1993 (1993-11-30) abstract column 5, line 29 - line 65	1,12,13
P,X	WO 99 12267 A (ROCKWELL SEMICONDUCTOR SYSTEMS) 11 March 1999 (1999-03-11) abstract page 1, line 5 -page 3, line 23 page 10, line 18 -page 12, line 15 page 13, line 27 -page 14, line 10 page 17, line 25 - line 29 page 21, line 26 -page 26, line 30 page 28, line 21 -page 29, line 10	1-13

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
EP 99/08361

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5825823 A	20-10-1998	NONE	
WO 9839866 A	11-09-1998	AU 6447798 A	22-09-1998
		EP 0916202 A	19-05-1999
WO 9817044 A	23-04-1998	US 5875229 A	23-02-1999
		AU 4903097 A	11-05-1998
		CN 1233369 A	27-10-1999
		DE 19782048 T	23-09-1999
		GB 2333662 A	28-07-1999
EP 0833481 A	01-04-1998	NO 974242 A	30-03-1998
		SE 9603532 A	28-03-1998
US 5793809 A	11-08-1998	NONE	
WO 9837657 A	27-08-1998	US 5859872 A	12-01-1999
		AU 6280798 A	09-09-1998
		CA 2261635 A	27-08-1998
		EP 0927469 A	07-07-1999
EP 0871303 A	14-10-1998	NONE	
EP 0735717 A	02-10-1996	US 5828696 A	27-10-1998
		CA 2170930 A	01-10-1996
		CN 1134637 A	30-10-1996
		IL 117650 A	17-08-1999
		JP 8288935 A	01-11-1996
WO 9813979 A	02-04-1998	AU 4736697 A	17-04-1998
		DE 19782004 T	09-09-1999
		GB 2332605 A	23-06-1999
US 5267300 A	30-11-1993	NONE	
WO 9912267 A	11-03-1999	AU 9126298 A	22-03-1999

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
1998P04747WO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/08361	02/11/1999	10/11/1998
International Patent Classification (IPC) or national classification and IPC H04L25/49		
Applicant INFINEON TECHNOLOGIES AG et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☒ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
09/06/2000	14.02.01
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Kappatou, E Telephone No. +49 89 2399 7521

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/08361

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

2,3,5-17	as originally filed			
1,1a,4	as received on	08/01/2001	with letter of	08/01/2001

Claims, No.:

1-5	as received on	08/01/2001	with letter of	08/01/2001

Drawings, sheets:

1/3-3/3	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	3,4
	No:	Claims	1,2,5
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-5
Industrial applicability (IA)	Yes:	Claims	1-5
	No:	Claims	

2. Citations and explanations
   see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following document:

   D1: US-A-5 825 823

2. The subject-matter of claim 1 is not new, Article 33(2) PCT.

2.1 The document D1 is regarded as being the closest prior art and discloses in particular in column 3, line 54 to column 6, line 36 (the references in parentheses applying to this document):

a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network (see column 1, lines 14 to 18),

wherein a first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point, (see transmitter and receiver in claim 1),

said method comprising the steps of:

a. said first subscriber terminal sending to said second subscriber terminal a digital probing signal (see column 4, lines 5 to 7) comprising
   i. a sequence of probing frames (see fig. 2a and 2b),
   ii. each probing frame comprising at least one frame portion (in fig. 2a: Frame 1 has 6 frame portions),
   iii. each frame portion comprising a preset number of digital symbols, each digital symbol having a sign bit and a data bit (see fig. 2a),
   iv. wherein the absolute digital values of the symbols in the frame portions are equal (e.g. in fig. 2a, the first frame portion has -975), and
   v. wherein the value of the sign bit changes with every adjacent frame

portion (see fig. 2a or 2b, different sign bit);

b. receiving a signal which is the result of said digital probing signal having been transmitted through said signal transmission channel by the second subscriber terminal (see column 6, lines 21 to 36);

c. evaluating said received signal by said second subscriber terminal wherein the received signal is compared with said digital probing signal to discriminate possible channel configurations of the signal transmission channel (see column 4, lines 5 to 7); and

d. transmitting a response signal from said second subscriber terminal to said first subscriber terminal, wherein the response signal carries information about the comparison result.

Feature d. is implied in document D1, since it is a common feature in the art of modems. For example, it can be found in the ITU-T Recommendation V.34, which is mentioned in both the application and D1 (in column 1, line 28).

2.2 It should be noted, that the absolute digital values of all the symbols of the digital probing signal, as suggested in D1, are indeed not equal in all frame portions. However, the current application claims, see lines 19 to 26 of claim, that the absolute values within a frame portion are equal and the sign bit changes every adjacent frame portion. This is what fig. 2 of D1 shows: frame 1 comprises 6 frame portions with value +/- 975 and a sign bit changing for every adjacent frame portion.

3. Claim 5 corresponds to claim 1, and is therefore also not new.

4. Dependent claims 2 to 4 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty or inventive step, because they are either disclosed in D1 (see fig. 2a and the above paragraphs), or merely straightforward possibilities from which the skilled person would select, in accordance with circumstances, without

the exercise of inventive skill, in order to solve the problem posed (e.g. choosing the total number of symbols per frame dependent on the expected digital impairment).

Re Item VI
Certain documents cited

Certain published documents (Rule 70.10)

Application No Patent No	Publication date *(day/month/year)*	Filing date *(day/month/year)*	Priority date *(valid claim)* *(day/month/year)*
WO 99/12267	11.03.1999	31.08.1998	03.09.1997, 13.11.1997

Re Item VII
Certain defects in the international application

1. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

2. Independent claims 1 and 5 are not in the two-part form in accordance with Rule 6.3(b) PCT.

Description

Method and apparatus of determining properties of a signal transmission channel

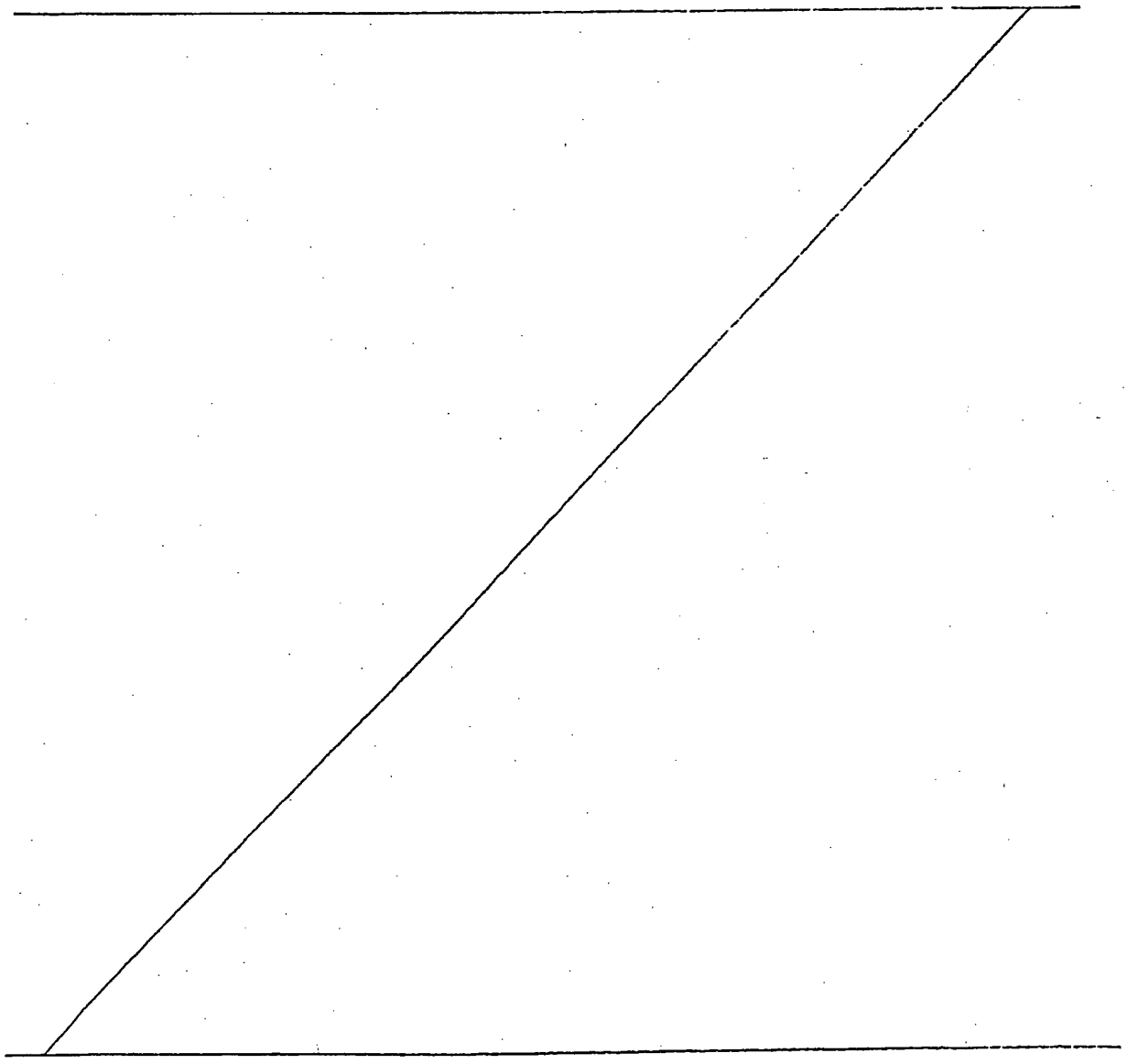
The invention relates to a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers, wherein a first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber, wherein said first subscriber end point is connected to the telephone network by a digital channel portion. The invention further relates to a subscriber terminal in a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, said subscriber terminal being connected to a subscriber end point of said telephone network.

The US patent US-A-5 825 823 describes a method of probing the state of a telecommunication channel, wherein transmitter generates two-level or three-level probing signal. The two-level or three-level probing signal is detected at a receiver which determines the presence and order of RB-signalling and PAD attenuation and the amount of PAD attenuation by comparing indications of transforms of the detecting probing signals to a plurality of threshold values.

Recently, substantial progress has been made in increasing the data transmission rates when transmitting data over conventional analogue telephone lines. The International Telecommunications Union (ITU) has promulgated and published

various recommendations, such as V.32, V.32bis, or V.34, that are concerned with data transmission over telephone lines. These recommendations are all based on a transmission technique called quadrature amplitude modulation (QAM). QAM has proven advantageous for the plain old telephone system (POTS) environment.

Nevertheless, the network of telephone system has undergone massive changes in that the network is nowadays almost



connected to the telephone network through a digital connection. This situation would allow to establish an all-digital channel between the two subscriber terminals at a data rate of 64 kbit/s, which is the standard data rate in telephone networks.

US 5,515,398 discloses modem line probing signal techniques. These probing techniques relate to former analogue line modems defined for example in ITU-T V.34.

It is an object of the invention to provide a line probing scheme in order to detect an all-digital connection path between subscriber terminals of a telephone network.

This object is achieved by a method having the features of claim 1. The object is further achieved by an apparatus having the features of claim 5. Advantageous embodiments thereof are set out in the respective dependent claims.

A first embodiment of the invention pertains to a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers. A first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point. Said telephone network upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber. Said first subscriber end point is connected to the telephone network by a digital channel portion. In a first step, said first subscriber terminal sends to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits. The digital values of all symbols over all frames are equal except for one bit position of each symbol, the

Claims

1. A method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network (3, 4, 5, 6) having a plurality of subscribers, wherein a first subscriber terminal (1) is connected to said first subscriber end point and a second subscriber terminal (8) is connected to said second subscriber end point, wherein the telephone network (3, 4, 5, 6) upon request of a subscriber establishes a signal transmission channel between said first subscriber end point and said second subscriber end point, wherein said first subscriber end point is connected to the telephone network (3, 4, 5, 6) by a digital channel portion (2), said method comprising the following steps:

sending a digital probing signal from said first subscriber terminal (1) to said second subscriber terminal (8), wherein the digital probing signal comprises a sequence of probing frames, each probing frame comprising at least one frame portion, each frame portion comprising a preset number of digital symbols, each digital symbol having a sign bit and data bit, wherein the absolute digital values of the symbols in the frame portions are equal and wherein the value of the sign bit changes with every adjacent frame portion,

receiving a signal which is the result of said digital probing signal having been transmitted through said signal transmission channel by the second subscriber terminal (8);

evaluating said received signal by said second subscriber terminal (8) wherein the received signal is compared with that digital probing signal to discriminate possible channel configurations of the signal transmission channel; and

transmitting a response signal from said second subscriber terminal (8) to said first subscriber terminal(1), wherein that response signal carries information about the comparison result.

2. The method according to claim 1, wherein all data bits of each symbol of a probing frame have the same logical value.

3. The method according to claim 1 characterised in that the total number of symbols of a probing frame is higher than an impulse response of a digital impairment of the signal transmission channel.

4. The method according to claim 3 characterised in that the total number of symbols per probing frame is 80.

5. A subscriber terminal connected to a subscriber end point of a telephone network having a plurality of the subscribers, comprising:
means for connecting said subscriber terminal (1) to a subscriber end point, said subscriber end point being connected to the telephone net work (3, 4, 5, 6) by a digital channel portion,
means for sending to a second subscriber terminal (8), to which a signal transmission channel has been established, a digital probing signal comprising a sequence of probing frames, each probing frame comprising at least one frame portion, each frame portion comprising a preset number of digital symbols, each digital symbol having a sign bit and data bits, wherein the absolute digital values of the symbols in the frame portions are equal and wherein the value of the sign bit changes with every adjacent frame portion.

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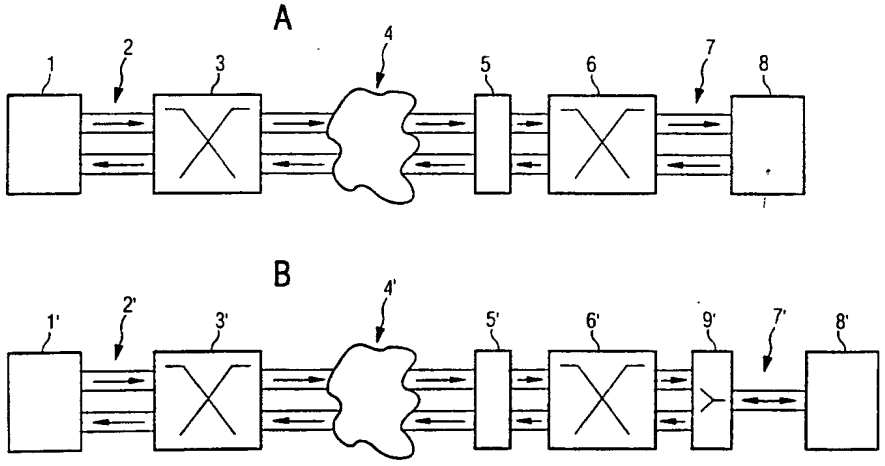

(57) Abstract

The invention generally relates to a modem connected via a digital interface to a switched public telephone network and to a method for probing the line properties. The modem communicates with a second modem also connected via a digital interface to the same switched public telephone network. The public telephone network may incorporate voice compression devices (ADPCM G.726, G.723 etc.), digital pads (digital attenuators), robbed bit signalling and echo cancelling devices. The probing sequence of the invention uses large amplitude changes in a symbol sequence (each symbol having a duration of 125 μs). After that single amplitude change, the signal may return to the previous value or continue with the new amplitude value for a number of symbols. The number of symbols is selected to be larger than any expected impulse response of a digital impairment of the channel. The amplitude value change must be large enough to produce a sufficient result in the presence of digital pads with or without the presence of RBS.

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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(54) Title: METHOD AND APPARATUS OF DETERMINING PROPERTIES OF A SIGNAL TRANSMISSION CHANNEL

(57) Abstract

The invention generally relates to a modem connected via a digital interface to a switched public telephone network and to a method for probing the line properties. The modem communicates with a second modem also connected via a digital interface to the same switched public telephone network. The public telephone network may incorporate voice compression devices (ADPCM G.726, G.723 etc.), digital pads (digital attenuators), robbed bit signalling and echo cancelling devices. The probing sequence of the invention uses large amplitude changes in a symbol sequence (each symbol having a duration of 125 μs). After that single amplitude change, the signal may return to the previous value or continue with the new amplitude value for a number of symbols. The number of symbols is selected to be larger than any expected impulse response of a digital impairment of the channel. The amplitude value change must be large enough to produce a sufficient result in the presence of digital pads with or without the presence of RBS.

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Description

Method and apparatus of determining properties of a signal transmission channel

The invention relates to a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers, wherein a first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber, wherein said first subscriber end point is connected to the telephone network by a digital channel portion. The invention further relates to a subscriber terminal in a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, said subscriber terminal being connected to a subscriber end point of said telephone network.

Recently, substantial progress has been made in increasing the data transmission rates when transmitting data over conventional analogue telephone lines. The International Telecommunications Union (ITU) has promulgated and published various recommendations, such as V.32, V.32bis, or V.34, that are concerned with data transmission over telephone lines. These recommendations are all based on a transmission technique called quadrature amplitude modulation (QAM). QAM has proven advantageous for the plain old telephone system (POTS) environment.

Nevertheless, the network of telephone system has undergone massive changes in that the network is nowadays almost

entirely digital. The analogue signals originating from a first subscriber modem are converted at the subscriber's central office to digital representations which are carried through the digital telephone network. At the central office of a second subscriber, the digital signals are converted back into analogue signals to be driven into a second subscriber's subscriber line. The second subscriber's modem interprets the analogue signals on the analogue subscriber line by demodulating the QAM signals produced by the first subscriber's modem. The same way of data communication is carried out in the reverse direction.

Increasingly more subscribers are connected to the telephone network through a digital subscriber interface, such as ISDN. Thus, many data connections are established between a first subscriber having an analogue network interface and a second subscriber having a digital network interface. In many cases, the second subscriber will be an internet service provider. In order to optimise data transmission over such heterogeneous communication channels, various proposals have been made in the recent past. One such proposal is known from US 5,801,695.

The proposal is based on the idea that the transmission rate in a heterogeneous communication channel from the digital subscriber to the analogue subscriber may be raised by using a PCM coding technique instead of the former QAM modulation techniques. The PCM coding technique uses a plurality of signal levels for encoding data symbols (each data symbol comprising multiple bits). These signal levels are again recognised by the receiving modem which is then able to decode the data symbol encoded into the signal levels.

Further, ITU has promulgated a new recommendation V.90 in September 1998. The new recommendation also relies on a PCM coding technique for the transmission of data from the digital subscriber to the analogue subscriber. Draft

recommendation V.90 in terms of its PCM coding scheme depends on ITU-T recommendation G.711 describing Pulse Code Modulation (PCM) of Voice Frequencies which is generally applied in telephone networks throughout the world when converting analogue signal amplitude values into numeric representations thereof, and vice versa. G.711 recommends two PCM coding schemes generally known as μ-law, which is applied in North American telephone networks, and A-law, which is applied in most other telephone networks. Both coding schemes have in common that they have a logarithmic coding characteristic, i.e. the lower the signal amplitude value to be encoded, the more fine-grain the available PCM codes. Such logarithmic coding characteristic has been found to be particularly advantageous for encoding analogue voice signals at minimum distortion.

Recommendation G.711 makes available 256 PCM codes (or U-codes as called in V.90) which are grouped into eight positive and eight negative segments (or U-chords as called in V.90). Each PCM code is encoded using eight bits. Due to power restrictions on the analogue telephone line and due to line impairments, the analogue modem (according to the terminology used in the draft to V.90) receiving analogue amplitude values is unable to discriminate between all 256 available PCM codes. Therefore, a reduced set of PCM codes is determined for encoding data symbols during set-up of a data communication channel under real world conditions. This accordingly lowers the data transmission rate down from the maximum theoretical possible value of 64 kbit/s such that it is not above 56 kbit/s.

ITU-T Recommendation V.90 assumes an environment where one subscriber terminal of a connection is connected to the telephone network through a digital line and the other subscriber terminal of the connection is connected to the telephone network through an analogue line. However, in many instances, both subscriber terminals of a connection are

connected to the telephone network through a digital connection. This situation would allow to establish an all-digital channel between the two subscriber terminals at a data rate of 64 kbit/s, which is the standard data rate in telephone networks.

US 5,151,398 discloses modem line probing signal techniques. These probing techniques relate to former analogue line modems defined for example in ITU-T V.34.

It is an object of the invention to provide a line probing scheme in order to detect an all-digital connection path between subscriber terminals of a telephone network.

This object is achieved by a method having the features of claim 1 or claim 4. The object is further achieved by an apparatus having the features of claim 11 or claim 12. Advantageous embodiments thereof are set out in the respective dependent claims.

A first embodiment of the invention pertains to a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers. A first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point. Said telephone network upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber. Said first subscriber end point is connected to the telephone network by a digital channel portion. In a first step, said first subscriber terminal sends to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits. The digital values of all symbols over all frames are equal except for one bit position of each symbol, the

value of which changes with every other frame. Said second subscriber terminal then receives a signal which is the result of said digital probing signal having been transmitted through said signal transmission channel. Said second subscriber terminal evaluates said received signal by comparing said received signal with said digital probing signal. Eventually, said second subscriber terminal transmitting a response signal to said first subscriber terminal, said response signal carrying information about the comparison result.

A second embodiment of the invention also concerns a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers. This method alternatively provides that said first subscriber terminal sends to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits, wherein the digital values of all symbols are equal except for at least one pulse symbol of each frame having a significantly different digital value compared to the remaining equal values.

The line probing schemes proposed by the invention allow both to find out whether an all-digital transmission channel is present between said first subscriber end point and said second subscriber end point and further to find out the transmission properties of the all-digital transmission channel. Since the transmission channels of most telephone networks are primarily intended for voice signal transmission, some networks impose digital signal impairments upon the digital signals carried through the network's channels. Such digital impairments include digital padding (digital signal attenuation), robbed bit signalling, ADPCM (Advanced Differential Pulse Code Modulation) coding and voice compression algorithms. The latter impairments allow to

reduce the bit rate of 64 kbit/s generally reserved for a full channel to a lower rate without much sacrifice to the quality of voice signal transmission, thus making available bandwidth for other purposes. The methods of the invention are capable of discriminating whether an all-digital channel is present and whether or not the all-digital channel has digital impairments. The methods of the invention are even capable of discriminating what kind of digital impairment is present in an all-digital transmission channel. Knowing the kind of digital impairment allows the conclusion as to whether a transmission scheme between said first subscriber terminal and said second subscriber terminal is possible according to V.90 or another lower rate scheme such as V.34.

In the first embodiment, it is preferred that said one bit position is the most significant bit position. This way, the absolute digital value difference from one frame to another is as large as possible. It is even further preferred that said one bit position is the position of the sign bit. This way of line probing ensures that no direct current is produced in an analogue channel portion which may be present in the transmission channel to be probed.

In the second embodiment, it is preferred that one bit position of said at least one pulse symbol changes value with every other frame. Thus, frames can be identified as such more easily by the second subscriber terminal. In an even more preferred embodiment, said one bit position is the position of the sign bit. This ensures that no direct current is produced in an analogue channel portion which may be present in the transmission channel to be probed.

In the second embodiment, it is preferred that the number of equal symbols per frame is significantly higher than the number of pulse symbols. This allows said second subscriber terminal to clearly identify a pulse symbol as such. Preferably, there is one pulse symbol per frame.

Alternatively, there may be two pulse symbols per frame. It is most preferred that the total number of symbols per frame is 80.

Further advantages, features and areas of using the invention are explained in the following description of a preferred embodiment of the invention which is to be read in conjunction with the attached drawings. In the drawings:

Fig. 1a shows the configuration of an all-digital signal transmission path in the presence of digital impairment;

Fig. 1b shows the configuration of a signal transmission path having an analogue portion;

Fig. 2 is a signal diagram of a probing signal and a received signal according to a first embodiment of the invention;

Fig. 3 depicts a digital symbol sequence of a probing signal and various received signals according to a second embodiment of the invention.

Fig. 1a illustrates an all-digital signal transmission path between a first subscriber terminal 1 and a second subscriber terminal 8. The first subscriber terminal 1 (a digital modem) is connected through a digital line portion 2 to a local digital switch 3. The local switch 3 is connected to a digital transmission network 4 which forwards digital signals between subscribers of the transmission network. On the other end of the all-digital signal path, the second subscriber terminal 8 is connected through a digital line portion 7 to a local digital switch 6. The local switch 6 is connected to the transmission network 4 through a digital impairment device 5. Fig. 1a shows an exemplary position of the digital impairment device within the transmission pat. The digital

impairment device may as well be part of any of the digital switches 3 and 6 or may be part of the transmission network 4 or of the transmission path 7.

Digital impairments include digital padding (digital signal attenuation), robbed bit signalling (RBS), and ADPCM (Advanced Differential Pulse Code Modulation) coding or other voice compression algorithms which may be imposed upon the signals passing through the impairment device 5. Digital impairment devices are present in many existing transmission networks and have to be accounted for when trying to establish a connection between subscriber terminals of the network at the highest bit rate possible.

Fig. 1b shows a similar configuration as Fig. 1a except that the second subscriber terminal 8' is connected to the transmission network through an analogue line portion 7'. The transmission path of Fig. 1a consequently includes a hybrid device 9' which is connected to the analogue line portion 7' and performs a four-wire to two-wire conversion. Additionally, the hybrid device 9' performs, on the four-wire side, a digital-to-analogue and an analogue-to-digital signal conversion so as to be connected to a digital switch 6'. The remaining structure of Fig. 1b corresponds to the one shown in Fig. 1a. Thus, the description of the remaining elements may be referred to by similar reference numerals.

Both Fig. 1a and Fig. 1b illustrate exemplary structures of transmission paths that may be encountered when trying to establish a connection between two subscribers of a transmission network wherein at least of the two subscribers is connected to the network through a digital line portion such as ISDN. Depending on the structure encountered on the transmission path between the subscribers, they may agree upon a certain transmission scheme allowing a bit rate as high as possible for the encountered structure. Known transmission schemes are ITU-T V.34 using quadrature

amplitude modulation on analogue transmission paths and ITU-T V.90 using pulse amplitude modulation on transmission paths having both analogue and digital line portions. Further, pulse amplitude modulation according to ITU-T V.90 can also be used as a transmission scheme on all-digital transmission paths.

Fig. 2 is a diagram of a probing signal of the first embodiment of the invention. The probing signal is transmitted by the first subscriber terminal 1 and of a signal received by the second subscriber terminal 8 in the presence of a digital impairment device 5 introducing ADPCM to the signal transmission path between the first subscriber and the second subscriber. Terminal 1 sends 80 digital symbols of equal value in a first frame and then sends 80 digital symbols of the same absolute value, however, being negative in sign. The probing signal consists of a plurality of frame pairs as illustrated in Fig. 2 subsequently transmitted by the first terminal 1.

In the presence of ADPCM in the transmission path, the received signal does not precisely follow the large signal swings from one frame to another. The second terminal 8 may interpret this as an all-digital transmission path which is not transparent due to ADPCM. Such a connection is not capable of carrying an ITU-T V.90 transmission scheme.

Fig. 3 shows a digital symbol sequence of a probing signal (sequence a) transmitted by the first subscriber terminal 1 (Modem 1) according to a second embodiment of the invention and various cases of received signals (sequences b through g). Fig. 3 shows a frame structure of 9 symbols per frame. It is preferred to use a much higher symbol count per frame, preferably 80 symbols per frame. Each digital symbol shown in Fig 3 is a hexadecimal representation of an 8 bit digital value corresponding to the U-code representation as defined in ITU-T V.90. The first symbol of the first probing frame in

sequence (a) is 4Ch (the character h indicating hexadecimal representation in this text). The first symbol of the second probing frame in sequence (a) is CCh, which is equal to 4Ch except for one bit position. According to ITU-T G.711, this bit position is the sign bit of a signal represented by the digital symbol. All remaining symbols are at value 00h. Thus, the first symbol forms a signal pulse.

Sequence (b) of Fig. 3 shows the signal received by subscriber terminal 8 (Modem 2) in the case of an all-digital, fully transparent connection. Thus the frame sent by modem 1 is received by modem 2 with identical symbols, merely displaced in time. This case allows to establish a PCM transmission scheme between modem 1 and modem 2. Sequence (b) through (g) show received signals in the presence of digital impairments. Sequence (c) assumes an impairment of digital padding, i.e. the digital signal is attenuated. Thus the pulse symbol in the original probing sequence (a) is lower in its absolute value.

Sequence (d) shows a received signal in the presence of digital impairment in the form of robbed bit signalling (RBS). RBS is applied to a least significant bit of every sixth symbol. Thus, the received signal differs from the original probing sequence every sixth symbol. Sequence (e) shows a received signal in the presence of both digital padding and RBS. Thus, the effects of both impairments appear as a superimposed effect on the received signal.

Finally, sequence (f) shows a received signal under the influence of ADPCM or another voice compression algorithm. The ADPCM coder cannot follow the high pulse symbol 4Ch of the probing sequence interspersed in the zero symbols 00h. Thus, the pulse symbol of modem 1 is received with a much wider pulse width and less high amplitude in modem 2. This is a clear indication of ADPCM.

The invention generally also relates to a modem connected via a digital interface to a switched public telephone network. The modem communicates with a second modem also connected via a digital interface to the same switched public telephone network. Thus, there may exist the possibility to set up a connection between both modems with a transmission rate of 64 kbit/s on the basis of coding voice signals with pulse code modulation according to ITU-T recommendation G.711. The public telephone network may incorporate voice compression devices (ADPCM G.726, G.723 etc.), digital pads (digital attenuators), robbed bit signalling and echo cancelling devices.

Under such circumstances, digital encoding schemes like pulse amplitude modulation according to ITU-T V. 90 instead of known analogue schemes like ITU-T V.34 may be utilised to transfer data. In order to apply such a digital coding scheme, it needs to be assured that an all-digital channel has been established between the modems. Assuring this may be carried out by an appropriate probing signal sent through the transmission channel. Known probing techniques have proven that they cannot discriminate all possible channel configurations.

The probing sequence of the invention uses large amplitude changes in a symbol sequence (each symbol having a duration of 125 µs). The meaning of amplitude relates to the definition of ITU-T recommendation G.711. After that single amplitude change, the signal may return to the previous value or continue with the new amplitude value for a number of symbols. The number of symbols is selected to be larger than any expected impulse response of a digital impairment of the channel. The amplitude value change must be large enough to produce a sufficient result in the presence of digital pads with or without the presence of RBS.

The receiving modem will evaluate the received symbols and search for amplitude changes. If these changes occur only for one symbol per frame and the following symbols either return to the previous value or remain at the new value, the connection is detected as capable to carry a V.90 transmission scheme. If, however, the symbols after an amplitude change do not remain at the new value or do not return to the value before the change (in other words there is an impulse response over time), it is determined, that a connection according to ITU-T V.90 is not possible. Typical impairments having an impulse response are voice compression algorithms and ADPCM, which may be regarded a compression algorithm, too. Whereas ADPCM has a characteristic impulse response to an change in amplitude, it depends on the design of a voice compression algorithm how large amplitude swings are processed and coded into the output signal of the voice compression coder.

Robbed bit signalling changes the least significant bit (LSB) in some symbols but leaves the remaining seven bits unchanged. A single amplitude change will therefore only be affected in the LSB, the remaining seven bits, however, will not change. Digital pads use conversion functions which defines an output value to a PCM input value thus providing digital attenuation. This function will only change the absolut value of the amplitude but it will not affect the behaviour of the signal over time.

In an implementation, modem 1 will generate a pattern as described in conjunction with Fig. 3 and sends the pattern through the transmission channel to modem 2. Modem 2 will receive a pattern which differs from the transmit pattern due to network impairments. Modem 2 will evaluate the pattern in the following way: It will first logical AND the pattern with FEh in order to ignore changes in the LSB. Next it will compare this new value with the previous one. If they are identical, a counter is incremented. If they are different,

then the current count value is compared to the expected value and if they differ, an error counter is incremented. Then the counter is reset to zero and the new value is transferred to the old value register. When all symbols have been evaluated, the value of the error counter is compared to a fixed threshold value. If the error counter value is below the threshold, then it is determined that the connection is not capable of carrying an ITU-T V.90 type transmission scheme.

The appended program codes show how line probing signals according to the invention may be produced. The programs are based on a pseudo code. The program of appendix A corresponds to the embodiment of Fig. 2, and the program of appendix B corresponds to the embodiment of Fig. 3. By no means are these program a limitation of the invention.

Appendix A

Example of program code for alternating pattern:

```
Transmit_Pattern:


Loop_COUNT = 20
High_Code = 4CH
Low_Code = CCH
Total_count = 100

For (i;I=0;I=Total_count)
     {
     For (j;J=1; j=Loop_Count)
          SendPCMvalue (Low_code);

     For (j;J=1;j=Loop_Count)
          SendPCMvalue(High_Code);
     }

Receiver:
Loop_Count = 20
Total_count = 100 * 2 * Loop_Count

Old = 0;
Error = 0;
Count = 0;

For (i;i=0;i=Total_count)
     {
     a = (GetnewPCMvalue() && 11111110B)          ;Masked LSB
for RBS impact
     If (Old <> a)
          count++
     ELSE
```

```
                IF (COUNT <> LOOP_COUNT-1)
                     Error++
                count = 0
          Old = a;
          }

    If (Error > 1)
          Return (False)
    Return (True)
```

Appendix B

Example code for single value pattern detection:

```
Transmit_Pattern:

Loop_COUNT = 20
High_Code = 4CH
Low_Code = 00H
Total_count = 100


For (i;I=0;I=Total_count)
     {
     For (j;J=1; j=Loop_Count-1)
          SendPCMvalue (Low_code);

     SendPCMvalue(High_Code);

     For (j;J=1; j=Loop_Count-1)
          SendPCMvalue (Low_code);

     SendPCMvalue(High_Code EXOR 80H);

     }

Receiver:
Loop_Count = 20
Total_count = 100 * (LoopCount)

Old = 0;
Error = 0;
Count = 0;

For (i;i=0;i=Total_count)
     {
```

```
     a = (GetnewPCMvalue() && 11111110B)          ;Masked LSB
for RBS impact
     If (Old <> a)
          count++
     ELSE
     {
          IF (COUNT <> LOOP_COUNT-2)
               IF (COUNT <> 0)
                    Error++
          count = 0
     Old = a;
     }

If (Error > 1)
     Return (False)
Return (True)
```

Claims

1. A method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers, wherein a first subscriber terminal (1) is connected to said first subscriber end point and a second subscriber terminal (8) is connected to said second subscriber end point, wherein said telephone network (3, 4, 5, 6) upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber, wherein said first subscriber end point is connected to the telephone network by a digital channel portion (2), said method comprising the steps of:

said first subscriber terminal sending to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising at least one frame portion, each frame portion comprising a sequence of digital symbols, each symbol having a plurality of bits, wherein each frame comprises a preset number of symbols, wherein the digital values of symbols in a frame portion are equal, and wherein the digital values of adjacent frame portions is significantly different;

said second subscriber terminal receiving a signal which is the result of said digital probing signal having been transmitted through said signal transmission channel;

said second subscriber terminal evaluating said received signal by comparing said received signal with said digital probing signal; and

said second subscriber terminal transmitting a response signal to said first subscriber terminal, said response signal carrying information about the comparison result.

2. The method of claim 1, characterised in that a frame comprises one frame portion (Fig. 2), wherein the digital values of all symbols over all frames are equal except for one bit position of each symbol, the value of which changes with every other frame.

3. The method of claim 2, characterised in that said one bit position is the most significant bit position.

4. The method of claims 2 or 3, characterised in that said one bit position is the position of the sign bit.

5. The method of claim 1, characterised in that a frame comprises at least two frame portions (Fig. 3), wherein the digital values of all symbols in a frame are equal except for at least one pulse symbol of each frame having a significantly different digital value compared to the remaining equal values.

6. The method of claim 5, characterised in that one bit position of said at least one pulse symbol changes value with every other frame.

7. The method of claim 6, characterised in that said one bit position is the position of the sign bit.

8. The method of any of claims 5 to 7, characterised in that the number of equal symbols per frame is significantly higher than the number of pulse symbols.

9. The method any of claim 5 to 7, characterised in that there is one pulse symbol per frame.

10. The method of claim 5 or 6, characterised in that there are two pulse symbols per frame.

11. The method of any of claims 5 to 10, characterised in that the total number of symbols per frame is 80.

12. In a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, a subscriber terminal connected to a subscriber end point of said telephone network comprising:

means for connecting said subscriber terminal to said subscriber end point, said subscriber end point being connected to the telephone network by a digital channel portion,

means for sending to a second subscriber terminal, to which a signal transmission channel has been established, a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits, wherein the digital values of all symbols over all frames are equal except for one bit position of each symbol, the value of which changes with every other frame.

13. In a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, a subscriber terminal connected to a subscriber end point of said telephone network comprising:

means for connecting said subscriber terminal to said subscriber end point, said subscriber end point being connected to the telephone network by a digital channel portion,

means for sending to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol

having a plurality of bits, wherein the digital values of all symbols are equal except for at least one symbol of each frame having a significantly different digital value compared to the remaining equal values.

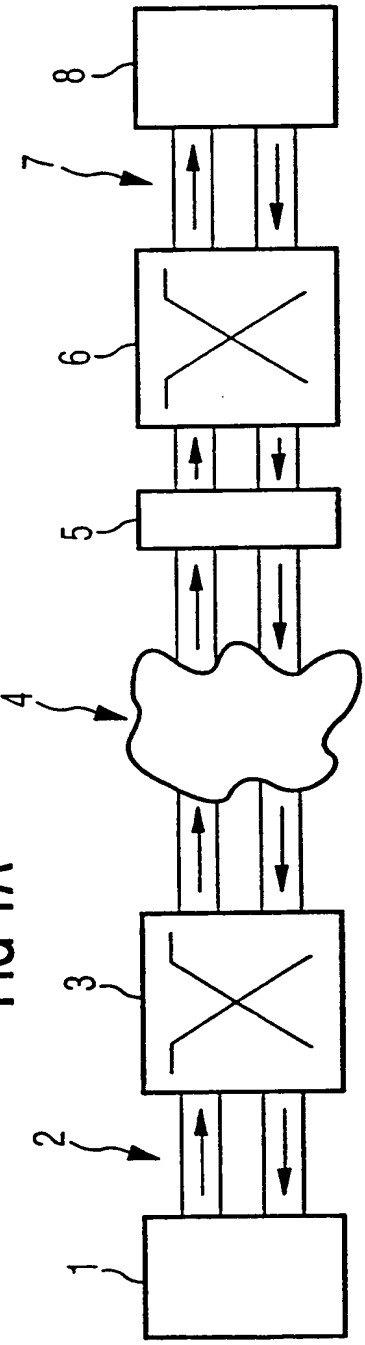


FIG 1A

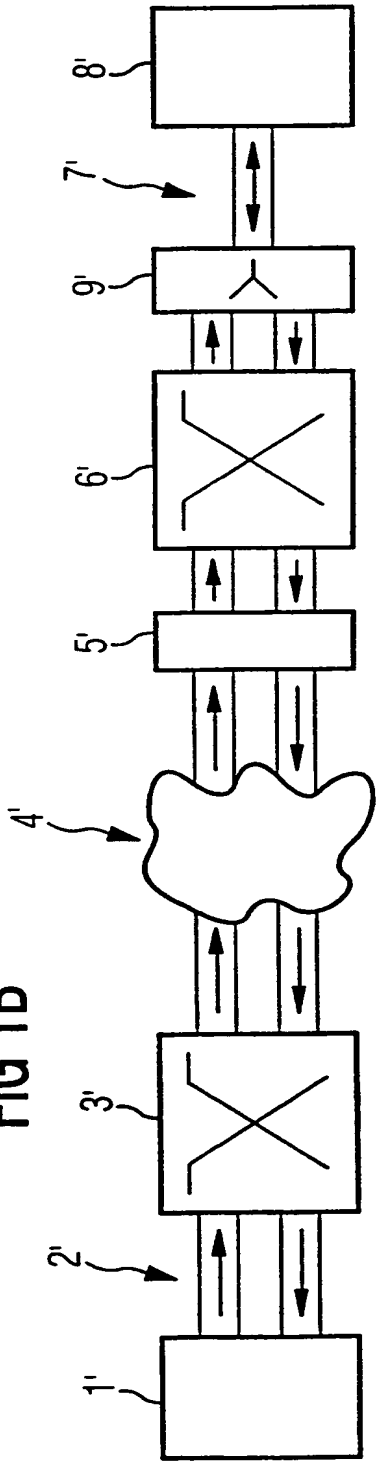


FIG 1B

FIG 2

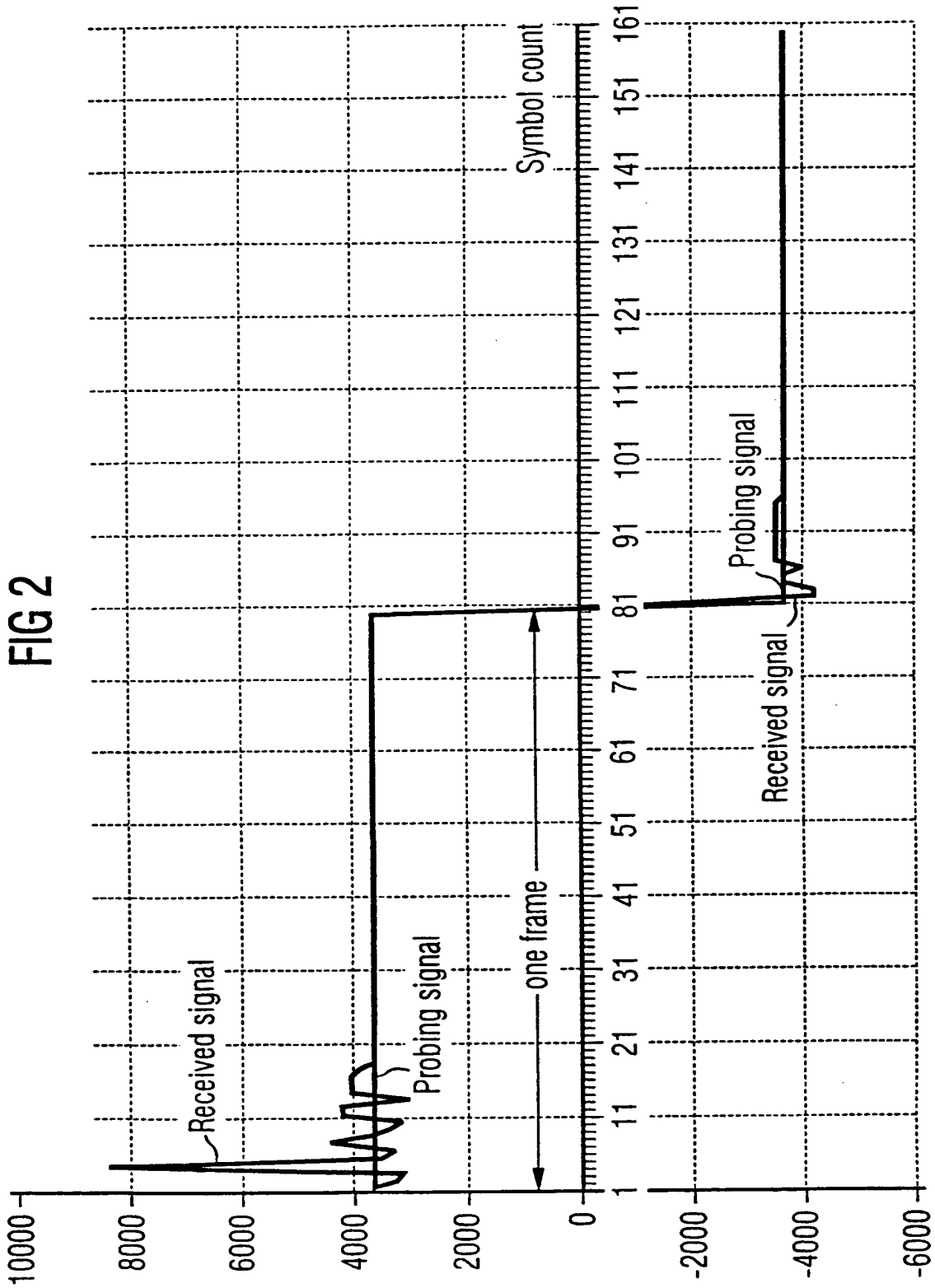
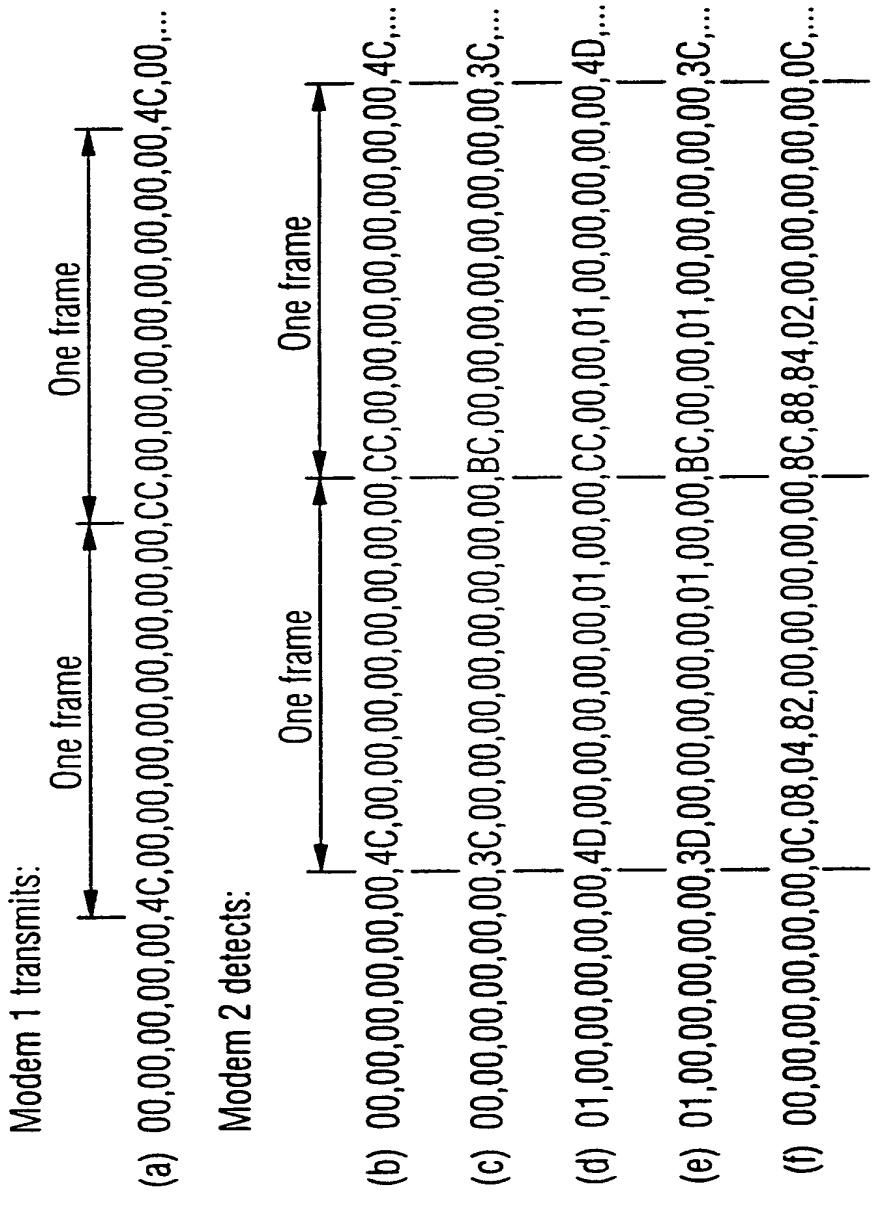

Symbol count
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
Received signal
Probing signal
one frame
Probing signal
Received signal

FIG 3


Modem 1 transmits:
One frame
One frame
(a) 00,00,00,00,00,4C,00,00,00,00,00,00,CC,00,00,00,00,00,00,4C,00,...
Modem 2 detects:
One frame
One frame
(b) 00,00,00,00,00,00,4C,00,00,00,00,00,00,CC,00,00,00,00,00,00,4C,...
(c) 00,00,00,00,00,00,3C,00,00,00,00,00,00,BC,00,00,00,00,00,00,3C,...
(d) 01,00,00,00,00,00,4D,00,00,00,00,01,00,00,CC,00,00,01,00,00,4D,...
(e) 01,00,00,00,00,00,3D,00,00,00,00,01,00,00,BC,00,00,01,00,00,3C,...
(f) 00,00,00,00,00,00,0C,08,04,82,00,00,00,00,00,8C,88,84,02,00,0C,...

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PCT REQUEST

GR98P4747P

Original (for **SUBMISSION**) - printed on 01.10.1999 09:02:46 AM

0	**For receiving Office use only**	
0-1	International Application No.	PCT/EP 99/08361
0-2	International Filing Date	02 NOV 1999 (02.11.99)
0-3	Name of receiving Office and "PCT International Application"	EUROPEAN PATENT OFFICE PCT INTERNATIONAL APPLICATION
0-4	**Form - PCT/RO/101 PCT Request**	
0-4-1	Prepared using	PCT-EASY Version 2.84 (updated 01.07.1999)
0-5	**Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	**Receiving Office (specified by the applicant)**	European Patent Office (EPO) (RO/EP)
0-7	**Applicant's or agent's file reference**	GR98P4747P
I	**Title of invention**	METHOD AND APPARATUS OF DETERMINING PROPERTIES OF A SIGNAL TRANSMISSION CHANNEL
II	**Applicant**	
II-1	This person is:	applicant only
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III-1-7	State of residence	DE

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IV-1	**Agent or common representative; or address for correspondence** The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	common representative
IV-1-1	Name	INFINEON TECHNOLOGIES AG
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IV-1-4	Facsimile No.	(089) 636-81857
V	**Designation of States**	
V-1	Regional Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT
V-2	National Patent (other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned)	CN JP KR US
V-5	**Precautionary Designation Statement** In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit.	
V-6	**Exclusion(s) from precautionary designations**	NONE
VI-1	**Priority claim of earlier regional application**	
VI-1-1	Filing date	10 November 1998 (10.11.1998)
VI-1-2	Number	98121134.5
VI-1-3	Regional Office	EP
VI-2	**Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s):	VI-1
VII-1	**International Searching Authority Chosen**	European Patent Office (EPO) (ISA/EP)

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VII-2	**Request to use results of earlier search; reference to that search**		
VII-2-1	Date	22 April 1999 (22.04.1999)	
VII-2-2	Number	EP 98121134	
VII-2-3	Country (or regional Office)	EP	
VIII	**Check list**	number of sheets	electronic file(s) attached
VIII-1	Request	4	-
VIII-2	Description	17	-
VIII-3	Claims	4	-
VIII-4	Abstract	1	98p4747p.txt
VIII-5	Drawings	3	-
VIII-7	TOTAL	29	
	Accompanying items	paper document(s) attached	electronic file(s) attached
VIII-8	Fee calculation sheet	✓	-
VIII-16	PCT-EASY diskette	-	diskette
VIII-18	**Figure of the drawings which should accompany the abstract**	-	
VIII-19	**Language of filing of the international application**	English	
IX-1	**Signature of applicant or agent**		
IX-1-1	Name	INFINEON TECHNOLOGIES AG	
IX-1-2	Name of signatory	Zedlitz	
IX-1-3	Capacity	European Patent Attorney	
IX-2	**Signature of applicant or agent**		
IX-2-1	Name (LAST, First)	HÖFER, Gerald	

FOR RECEIVING OFFICE USE ONLY

10-1	**Date of actual receipt of the purported international application**	02 NOV 1999 (02. 11. 99)
10-2	**Drawings:**	
10-2-1	Received	x
10-2-2	Not received	
10-3	**Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application**	
10-4	**Date of timely receipt of the required corrections under PCT Article 11(2)**	
10-5	**International Searching Authority**	ISA/EP
10-6	**Transmittal of search copy delayed until search fee is paid**	

PCT REQUEST

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FOR INTERNATIONAL BUREAU USE ONLY

11-1	Date of receipt of the record copy by the International Bureau	29 MARCH 2000	(29. 03. 00)

Description

Method and apparatus of determining properties of a signal transmission channel

The invention relates to a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers, wherein a first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber, wherein said first subscriber end point is connected to the telephone network by a digital channel portion. The invention further relates to a subscriber terminal in a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, said subscriber terminal being connected to a subscriber end point of said telephone network.

Recently, substantial progress has been made in increasing the data transmission rates when transmitting data over conventional analogue telephone lines. The International Telecommunications Union (ITU) has promulgated and published various recommendations, such as V.32, V.32bis, or V.34, that are concerned with data transmission over telephone lines. These recommendations are all based on a transmission technique called quadrature amplitude modulation (QAM). QAM has proven advantageous for the plain old telephone system (POTS) environment.

Nevertheless, the network of telephone system has undergone massive changes in that the network is nowadays almost

entirely digital. The analogue signals originating from a first subscriber modem are converted at the subscriber's central office to digital representations which are carried through the digital telephone network. At the central office of a second subscriber, the digital signals are converted back into analogue signals to be driven into a second subscriber's subscriber line. The second subscriber's modem interprets the analogue signals on the analogue subscriber line by demodulating the QAM signals produced by the first subscriber's modem. The same way of data communication is carried out in the reverse direction.

Increasingly more subscribers are connected to the telephone network through a digital subscriber interface, such as ISDN. Thus, many data connections are established between a first subscriber having an analogue network interface and a second subscriber having a digital network interface. In many cases, the second subscriber will be an internet service provider. In order to optimise data transmission over such heterogeneous communication channels, various proposals have been made in the recent past. One such proposal is known from US 5,801,695.

The proposal is based on the idea that the transmission rate in a heterogeneous communication channel from the digital subscriber to the analogue subscriber may be raised by using a PCM coding technique instead of the former QAM modulation techniques. The PCM coding technique uses a plurality of signal levels for encoding data symbols (each data symbol comprising multiple bits). These signal levels are again recognised by the receiving modem which is then able to decode the data symbol encoded into the signal levels.

Further, ITU has promulgated a new recommendation V.90 in September 1998. The new recommendation also relies on a PCM coding technique for the transmission of data from the digital subscriber to the analogue subscriber. Draft

recommendation V.90 in terms of its PCM coding scheme depends on ITU-T recommendation G.711 describing Pulse Code Modulation (PCM) of Voice Frequencies which is generally applied in telephone networks throughout the world when converting analogue signal amplitude values into numeric representations thereof, and vice versa. G.711 recommends two PCM coding schemes generally known as μ-law, which is applied in North American telephone networks, and A-law, which is applied in most other telephone networks. Both coding schemes have in common that they have a logarithmic coding characteristic, i.e. the lower the signal amplitude value to be encoded, the more fine-grain the available PCM codes. Such logarithmic coding characteristic has been found to be particularly advantageous for encoding analogue voice signals at minimum distortion.

Recommendation G.711 makes available 256 PCM codes (or U-codes as called in V.90) which are grouped into eight positive and eight negative segments (or U-chords as called in V.90). Each PCM code is encoded using eight bits. Due to power restrictions on the analogue telephone line and due to line impairments, the analogue modem (according to the terminology used in the draft to V.90) receiving analogue amplitude values is unable to discriminate between all 256 available PCM codes. Therefore, a reduced set of PCM codes is determined for encoding data symbols during set-up of a data communication channel under real world conditions. This accordingly lowers the data transmission rate down from the maximum theoretical possible value of 64 kbit/s such that it is not above 56 kbit/s.

ITU-T Recommendation V.90 assumes an environment where one subscriber terminal of a connection is connected to the telephone network through a digital line and the other subscriber terminal of the connection is connected to the telephone network through an analogue line. However, in many instances, both subscriber terminals of a connection are

connected to the telephone network through a digital connection. This situation would allow to establish an all-digital channel between the two subscriber terminals at a data rate of 64 kbit/s, which is the standard data rate in telephone networks.

US 5,151,398 discloses modem line probing signal techniques. These probing techniques relate to former analogue line modems defined for example in ITU-T V.34.

It is an object of the invention to provide a line probing scheme in order to detect an all-digital connection path between subscriber terminals of a telephone network.

This object is achieved by a method having the features of claim 1 or claim 4. The object is further achieved by an apparatus having the features of claim 11 or claim 12. Advantageous embodiments thereof are set out in the respective dependent claims.

A first embodiment of the invention pertains to a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers. A first subscriber terminal is connected to said first subscriber end point and a second subscriber terminal is connected to said second subscriber end point. Said telephone network upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber. Said first subscriber end point is connected to the telephone network by a digital channel portion. In a first step, said first subscriber terminal sends to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits. The digital values of all symbols over all frames are equal except for one bit position of each symbol, the

value of which changes with every other frame. Said second subscriber terminal then receives a signal which is the result of said digital probing signal having been transmitted through said signal transmission channel. Said second subscriber terminal evaluates said received signal by comparing said received signal with said digital probing signal. Eventually, said second subscriber terminal transmitting a response signal to said first subscriber terminal, said response signal carrying information about the comparison result.

A second embodiment of the invention also concerns a method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers. This method alternatively provides that said first subscriber terminal sends to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits, wherein the digital values of all symbols are equal except for at least one pulse symbol of each frame having a significantly different digital value compared to the remaining equal values.

The line probing schemes proposed by the invention allow both to find out whether an all-digital transmission channel is present between said first subscriber end point and said second subscriber end point and further to find out the transmission properties of the all-digital transmission channel. Since the transmission channels of most telephone networks are primarily intended for voice signal transmission, some networks impose digital signal impairments upon the digital signals carried through the network's channels. Such digital impairments include digital padding (digital signal attenuation), robbed bit signalling, ADPCM (Advanced Differential Pulse Code Modulation) coding and voice compression algorithms. The latter impairments allow to

reduce the bit rate of 64 kbit/s generally reserved for a full channel to a lower rate without much sacrifice to the quality of voice signal transmission, thus making available bandwidth for other purposes. The methods of the invention are capable of discriminating whether an all-digital channel is present and whether or not the all-digital channel has digital impairments. The methods of the invention are even capable of discriminating what kind of digital impairment is present in an all-digital transmission channel. Knowing the kind of digital impairment allows the conclusion as to whether a transmission scheme between said first subscriber terminal and said second subscriber terminal is possible according to V.90 or another lower rate scheme such as V.34.

In the first embodiment, it is preferred that said one bit position is the most significant bit position. This way, the absolute digital value difference from one frame to another is as large as possible. It is even further preferred that said one bit position is the position of the sign bit. This way of line probing ensures that no direct current is produced in an analogue channel portion which may be present in the transmission channel to be probed.

In the second embodiment, it is preferred that one bit position of said at least one pulse symbol changes value with every other frame. Thus, frames can be identified as such more easily by the second subscriber terminal. In an even more preferred embodiment, said one bit position is the position of the sign bit. This ensures that no direct current is produced in an analogue channel portion which may be present in the transmission channel to be probed.

In the second embodiment, it is preferred that the number of equal symbols per frame is significantly higher than the number of pulse symbols. This allows said second subscriber terminal to clearly identify a pulse symbol as such. Preferably, there is one pulse symbol per frame.

Alternatively, there may be two pulse symbols per frame. It is most preferred that the total number of symbols per frame is 80.

Further advantages, features and areas of using the invention are explained in the following description of a preferred embodiment of the invention which is to be read in conjunction with the attached drawings. In the drawings:

Fig. 1a shows the configuration of an all-digital signal transmission path in the presence of digital impairment;

Fig. 1b shows the configuration of a signal transmission path having an analogue portion;

Fig. 2 is a signal diagram of a probing signal and a received signal according to a first embodiment of the invention;

Fig. 3 depicts a digital symbol sequence of a probing signal and various received signals according to a second embodiment of the invention.

Fig. 1a illustrates an all-digital signal transmission path between a first subscriber terminal 1 and a second subscriber terminal 8. The first subscriber terminal 1 (a digital modem) is connected through a digital line portion 2 to a local digital switch 3. The local switch 3 is connected to a digital transmission network 4 which forwards digital signals between subscribers of the transmission network. On the other end of the all-digital signal path, the second subscriber terminal 8 is connected through a digital line portion 7 to a local digital switch 6. The local switch 6 is connected to the transmission network 4 through a digital impairment device 5. Fig. 1a shows an exemplary position of the digital impairment device within the transmission pat. The digital

impairment device may as well be part of any of the digital switches 3 and 6 or may be part of the transmission network 4 or of the transmission path 7.

Digital impairments include digital padding (digital signal attenuation), robbed bit signalling (RBS), and ADPCM (Advanced Differential Pulse Code Modulation) coding or other voice compression algorithms which may be imposed upon the signals passing through the impairment device 5. Digital impairment devices are present in many existing transmission networks and have to be accounted for when trying to establish a connection between subscriber terminals of the network at the highest bit rate possible.

Fig. 1b shows a similar configuration as Fig. 1a except that the second subscriber terminal 8' is connected to the transmission network through an analogue line portion 7'. The transmission path of Fig. 1a consequently includes a hybrid device 9' which is connected to the analogue line portion 7' and performs a four-wire to two-wire conversion. Additionally, the hybrid device 9' performs, on the four-wire side, a digital-to-analogue and an analogue-to-digital signal conversion so as to be connected to a digital switch 6'. The remaining structure of Fig. 1b corresponds to the one shown in Fig. 1a. Thus, the description of the remaining elements may be referred to by similar reference numerals.

Both Fig. 1a and Fig. 1b illustrate exemplary structures of transmission paths that may be encountered when trying to establish a connection between two subscribers of a transmission network wherein at least of the two subscribers is connected to the network through a digital line portion such as ISDN. Depending on the structure encountered on the transmission path between the subscribers, they may agree upon a certain transmission scheme allowing a bit rate as high as possible for the encountered structure. Known transmission schemes are ITU-T V.34 using quadrature

amplitude modulation on analogue transmission paths and ITU-T V.90 using pulse amplitude modulation on transmission paths having both analogue and digital line portions. Further, pulse amplitude modulation according to ITU-T V.90 can also be used as a transmission scheme on all-digital transmission paths.

Fig. 2 is a diagram of a probing signal of the first embodiment of the invention. The probing signal is transmitted by the first subscriber terminal 1 and of a signal received by the second subscriber terminal 8 in the presence of a digital impairment device 5 introducing ADPCM to the signal transmission path between the first subscriber and the second subscriber. Terminal 1 sends 80 digital symbols of equal value in a first frame and then sends 80 digital symbols of the same absolute value, however, being negative in sign. The probing signal consists of a plurality of frame pairs as illustrated in Fig. 2 subsequently transmitted by the first terminal 1.

In the presence of ADPCM in the transmission path, the received signal does not precisely follow the large signal swings from one frame to another. The second terminal 8 may interpret this as an all-digital transmission path which is not transparent due to ADPCM. Such a connection is not capable of carrying an ITU-T V.90 transmission scheme.

Fig. 3 shows a digital symbol sequence of a probing signal (sequence a) transmitted by the first subscriber terminal 1 (Modem 1) according to a second embodiment of the invention and various cases of received signals (sequences b through g). Fig. 3 shows a frame structure of 9 symbols per frame. It is preferred to use a much higher symbol count per frame, preferably 80 symbols per frame. Each digital symbol shown in Fig 3 is a hexadecimal representation of an 8 bit digital value corresponding to the U-code representation as defined in ITU-T V.90. The first symbol of the first probing frame in

sequence (a) is 4Ch (the character h indicating hexadecimal representation in this text). The first symbol of the second probing frame in sequence (a) is CCh, which is equal to 4Ch except for one bit position. According to ITU-T G.711, this bit position is the sign bit of a signal represented by the digital symbol. All remaining symbols are at value 00h. Thus, the first symbol forms a signal pulse.

Sequence (b) of Fig. 3 shows the signal received by subscriber terminal 8 (Modem 2) in the case of an all-digital, fully transparent connection. Thus the frame sent by modem 1 is received by modem 2 with identical symbols, merely displaced in time. This case allows to establish a PCM transmission scheme between modem 1 and modem 2. Sequence (b) through (g) show received signals in the presence of digital impairments. Sequence (c) assumes an impairment of digital padding, i.e. the digital signal is attenuated. Thus the pulse symbol in the original probing sequence (a) is lower in its absolute value.

Sequence (d) shows a received signal in the presence of digital impairment in the form of robbed bit signalling (RBS). RBS is applied to a least significant bit of every sixth symbol. Thus, the received signal differs from the original probing sequence every sixth symbol. Sequence (e) shows a received signal in the presence of both digital padding and RBS. Thus, the effects of both impairments appear as a superimposed effect on the received signal.

Finally, sequence (f) shows a received signal under the influence of ADPCM or another voice compression algorithm. The ADPCM coder cannot follow the high pulse symbol 4Ch of the probing sequence interspersed in the zero symbols 00h. Thus, the pulse symbol of modem 1 is received with a much wider pulse width and less high amplitude in modem 2. This is a clear indication of ADPCM.

The invention generally also relates to a modem connected via a digital interface to a switched public telephone network. The modem communicates with a second modem also connected via a digital interface to the same switched public telephone network. Thus, there may exist the possibility to set up a connection between both modems with a transmission rate of 64 kbit/s on the basis of coding voice signals with pulse code modulation according to ITU-T recommendation G.711. The public telephone network may incorporate voice compression devices (ADPCM G.726, G.723 etc.), digital pads (digital attenuators), robbed bit signalling and echo cancelling devices.

Under such circumstances, digital encoding schemes like pulse amplitude modulation according to ITU-T V. 90 instead of known analogue schemes like ITU-T V.34 may be utilised to transfer data. In order to apply such a digital coding scheme, it needs to be assured that an all-digital channel has been established between the modems. Assuring this may be carried out by an appropriate probing signal sent through the transmission channel. Known probing techniques have proven that they cannot discriminate all possible channel configurations.

The probing sequence of the invention uses large amplitude changes in a symbol sequence (each symbol having a duration of 125 µs). The meaning of amplitude relates to the definition of ITU-T recommendation G.711. After that single amplitude change, the signal may return to the previous value or continue with the new amplitude value for a number of symbols. The number of symbols is selected to be larger than any expected impulse response of a digital impairment of the channel. The amplitude value change must be large enough to produce a sufficient result in the presence of digital pads with or without the presence of RBS.

The receiving modem will evaluate the received symbols and search for amplitude changes. If these changes occur only for one symbol per frame and the following symbols either return to the previous value or remain at the new value, the connection is detected as capable to carry a V.90 transmission scheme. If, however, the symbols after an amplitude change do not remain at the new value or do not return to the value before the change (in other words there is an impulse response over time), it is determined, that a connection according to ITU-T V.90 is not possible. Typical impairments having an impulse response are voice compression algorithms and ADPCM, which may be regarded a compression algorithm, too. Whereas ADPCM has a characteristic impulse response to an change in amplitude, it depends on the design of a voice compression algorithm how large amplitude swings are processed and coded into the output signal of the voice compression coder.

Robbed bit signalling changes the least significant bit (LSB) in some symbols but leaves the remaining seven bits unchanged. A single amplitude change will therefore only be affected in the LSB, the remaining seven bits, however, will not change. Digital pads use conversion functions which defines an output value to a PCM input value thus providing digital attenuation. This function will only change the absolut value of the amplitude but it will not affect the behaviour of the signal over time.

In an implementation, modem 1 will generate a pattern as described in conjunction with Fig. 3 and sends the pattern through the transmission channel to modem 2. Modem 2 will receive a pattern which differs from the transmit pattern due to network impairments. Modem 2 will evaluate the pattern in the following way: It will first logical AND the pattern with FEh in order to ignore changes in the LSB. Next it will compare this new value with the previous one. If they are identical, a counter is incremented. If they are different,

then the current count value is compared to the expected value and if they differ, an error counter is incremented. Then the counter is reset to zero and the new value is transferred to the old value register. When all symbols have been evaluated, the value of the error counter is compared to a fixed threshold value. If the error counter value is below the threshold, then it is determined that the connection is not capable of carrying an ITU-T V.90 type transmission scheme.

The appended program codes show how line probing signals according to the invention may be produced. The programs are based on a pseudo code. The program of appendix A corresponds to the embodiment of Fig. 2, and the program of appendix B corresponds to the embodiment of Fig. 3. By no means are these program a limitation of the invention.

Appendix A

Example of program code for alternating pattern:

```
Transmit_Pattern:


Loop_COUNT = 20
High_Code = 4CH
Low_Code = CCH
Total_count = 100

For (i;I=0;I=Total_count)
     {
     For (j;J=1; j=Loop_Count)
          SendPCMvalue (Low_code);

     For (j;J=1;j=Loop_Count)
          SendPCMvalue(High_Code);
     }

Receiver:
Loop_Count = 20
Total_count = 100 * 2 * Loop_Count

Old = 0;
Error = 0;
Count = 0;

For (i;i=0;i=Total_count)
     {
     a = (GetnewPCMvalue() && 11111110B)          ;Masked LSB
for RBS impact
     If (Old <> a)
          count++
     ELSE
```

```
            IF (COUNT <> LOOP_COUNT-1)
                 Error++
            count = 0
       Old = a;
       }

If (Error > 1)
     Return (False)
Return (True)
```

Appendix B

Example code for single value pattern detection:

```
Transmit_Pattern:

Loop_COUNT = 20
High_Code = 4CH
Low_Code = 00H
Total_count = 100


For (i;I=0;I=Total_count)
     {
     For (j;J=1; j=Loop_Count-1)
          SendPCMvalue (Low_code);

     SendPCMvalue(High_Code);

     For (j;J=1; j=Loop_Count-1)
          SendPCMvalue (Low_code);

     SendPCMvalue(High_Code EXOR 80H);

     }

Receiver:
Loop_Count = 20
Total_count = 100 * (LoopCount)

Old = 0;
Error = 0;
Count = 0;

For (i;i=0;i=Total_count)
     {
```

```
     a = (GetnewPCMvalue() && 11111110B)          ;Masked LSB
for RBS impact
     If (Old <> a)
          count++
     ELSE
     {
          IF (COUNT <> LOOP_COUNT-2)
               IF (COUNT <> 0)
                    Error++
          count = 0
     Old = a;
     }

If (Error > 1)
     Return (False)
Return (True)
```

Claims

1. A method of determining properties of a signal transmission channel between a first subscriber end point and a second subscriber end point of a telephone network having a plurality of subscribers, wherein a first subscriber terminal (1) is connected to said first subscriber end point and a second subscriber terminal (8) is connected to said second subscriber end point, wherein said telephone network (3, 4, 5, 6) upon request of a subscriber establishes a signal transmission channel between said first subscriber and said second subscriber, wherein said first subscriber end point is connected to the telephone network by a digital channel portion (2), said method comprising the steps of:

said first subscriber terminal sending to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising at least one frame portion, each frame portion comprising a sequence of digital symbols, each symbol having a plurality of bits, wherein each frame comprises a preset number of symbols, wherein the digital values of symbols in a frame portion are equal, and wherein the digital values of adjacent frame portions is significantly different;

said second subscriber terminal receiving a signal which is the result of said digital probing signal having been transmitted through said signal transmission channel;

said second subscriber terminal evaluating said received signal by comparing said received signal with said digital probing signal; and

said second subscriber terminal transmitting a response signal to said first subscriber terminal, said response signal carrying information about the comparison result.

2. The method of claim 1, characterised in that a frame comprises one frame portion (Fig. 2), wherein the digital values of all symbols over all frames are equal except for one bit position of each symbol, the value of which changes with every other frame.

3. The method of claim 2, characterised in that said one bit position is the most significant bit position.

4. The method of claims 2 or 3, characterised in that said one bit position is the position of the sign bit.

5. The method of claim 1, characterised in that a frame comprises at least two frame portions (Fig. 3), wherein the digital values of all symbols in a frame are equal except for at least one pulse symbol of each frame having a significantly different digital value compared to the remaining equal values.

6. The method of claim 5, characterised in that one bit position of said at least one pulse symbol changes value with every other frame.

7. The method of claim 6, characterised in that said one bit position is the position of the sign bit.

8. The method of any of claims 5 to 7, characterised in that the number of equal symbols per frame is significantly higher than the number of pulse symbols.

9. The method any of claim 5 to 7, characterised in that there is one pulse symbol per frame.

10. The method of claim 5 or 6, characterised in that there are two pulse symbols per frame.

11. The method of any of claims 5 to 10, characterised in that the total number of symbols per frame is 80.

12. In a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, a subscriber terminal connected to a subscriber end point of said telephone network comprising:

means for connecting said subscriber terminal to said subscriber end point, said subscriber end point being connected to the telephone network by a digital channel portion,

means for sending to a second subscriber terminal, to which a signal transmission channel has been established, a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol having a plurality of bits, wherein the digital values of all symbols over all frames are equal except for one bit position of each symbol, the value of which changes with every other frame.

13. In a telephone network having a plurality of subscribers, wherein said telephone network upon request of a subscriber establishes a signal transmission channel between selected subscribers, a subscriber terminal connected to a subscriber end point of said telephone network comprising:

means for connecting said subscriber terminal to said subscriber end point, said subscriber end point being connected to the telephone network by a digital channel portion,

means for sending to said second subscriber terminal a digital probing signal comprising a sequence of frames, each frame comprising a sequence of digital symbols, each symbol

having a plurality of bits, wherein the digital values of all symbols are equal except for at least one symbol of each frame having a significantly different digital value compared to the remaining equal values.

Abstract

The invention generally relates to a modem connected via a digital interface to a switched public telephone network and to method for probing the line properties. The modem communicates with a second modem also connected via a digital interface to the same switched public telephone network. The public telephone network may incorporate voice compression devices (ADPCM G.726, G.723 etc.), digital pads (digital attenuators), robbed bit signalling and echo cancelling devices. The probing sequence of the invention uses large amplitude changes in a symbol sequence (each symbol having a duration of 125 µs). After that single amplitude change, the signal may return to the previous value or continue with the new amplitude value for a number of symbols. The number of symbols is selected to be larger than any expected impulse response of a digital impairment of the channel. The amplitude value change must be large enough to produce a sufficient result in the presence of digital pads with or without the presence of RBS.

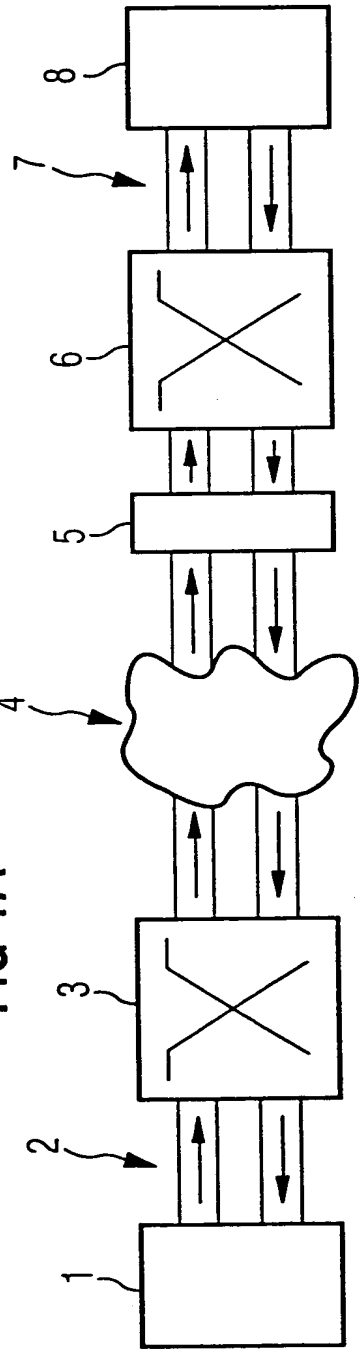


FIG 1A

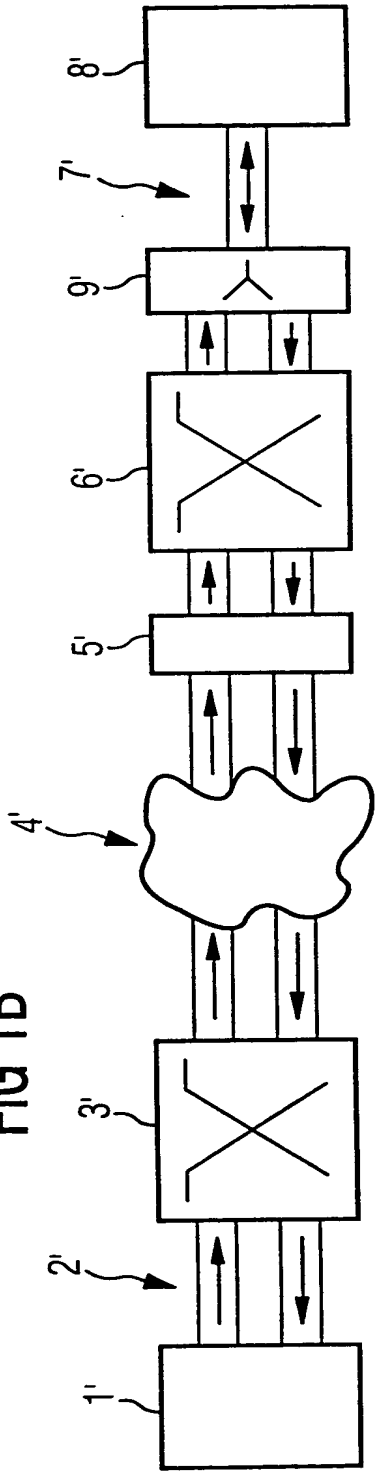


FIG 1B

FIG 2

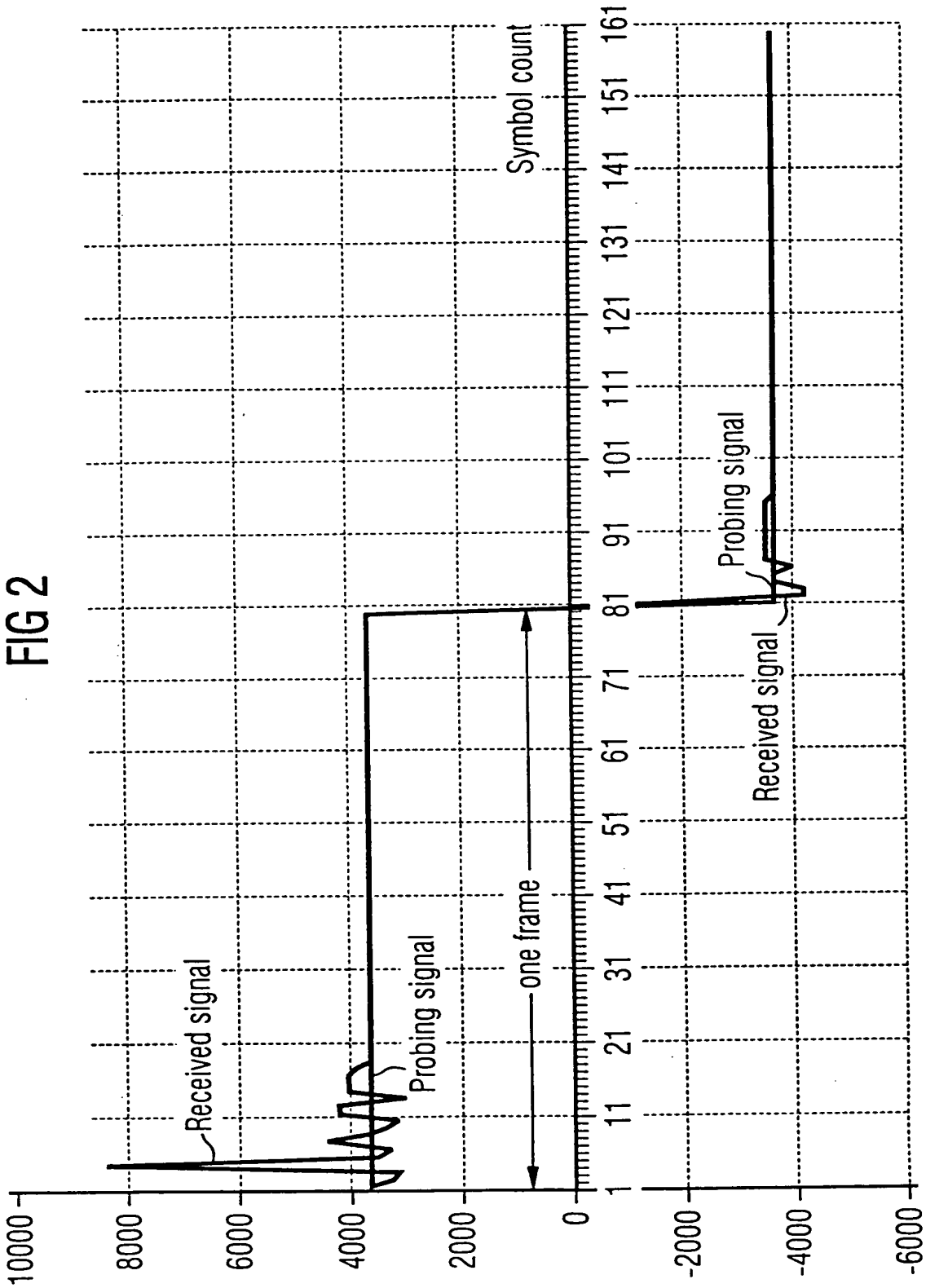
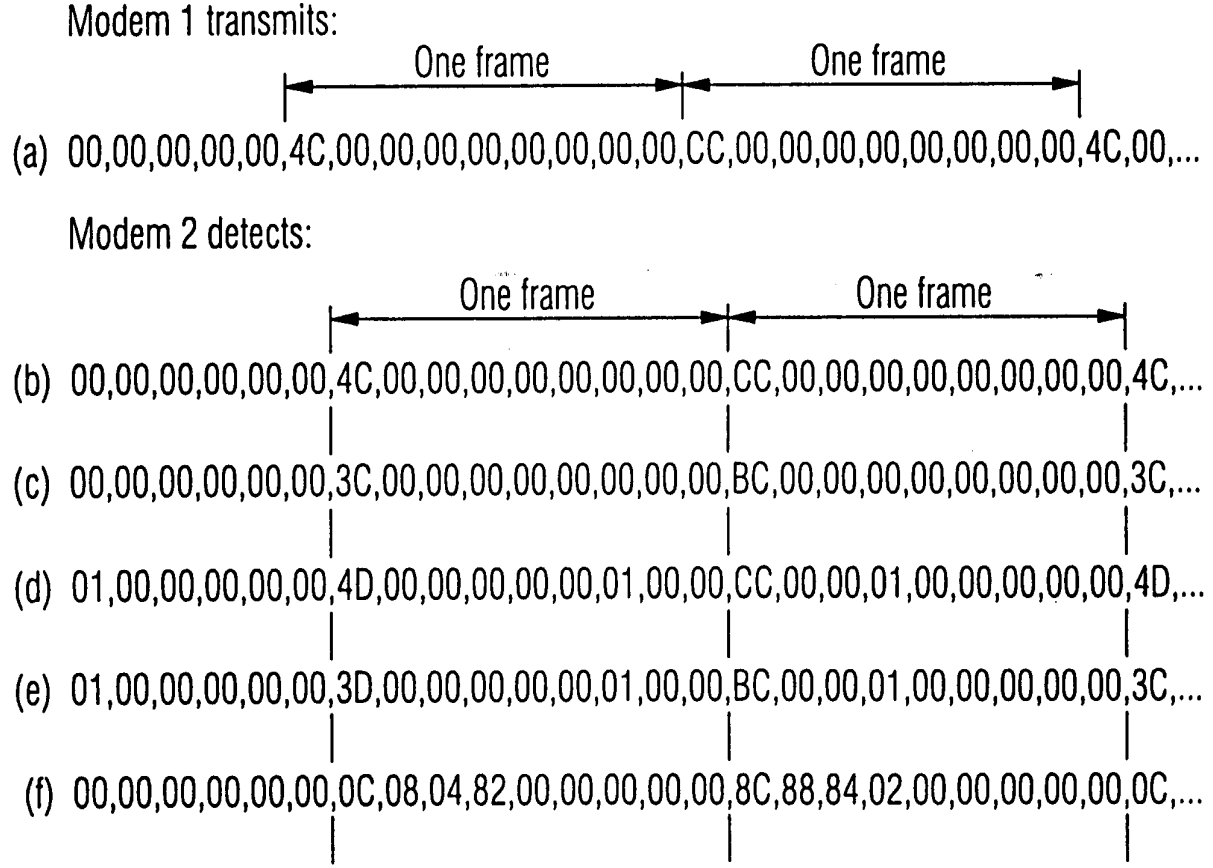

Symbol count
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
161
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
Received signal
Probing signal
one frame
Probing signal
Received signal

FIG 3



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